Pigments of the Earliest Northumbrian Manuscripts

This article reports the findings of a campaign of non-destructive pigment analysis on a group of seventh- and eighth-century Northumbrian manuscripts, including the Durham Gospels. Integrating this critical mass of new information with the previously available data about related volumes such as Codex Amiatinus and the Lindisfarne Gospels, it reassesses the palette of, and the use of colour in, early Northumbrian manuscripts more generally.

The quantity of reliable scientific information about the pigments used in the earliest Northumbrian manuscripts has expanded slowly but surely in recent years. Despite the availability for over three decades of suitable non-invasive, non-destructive techniques for identifying the nature of many colour stuffs[1], the high insurance costs attendant upon moving extremely precious early medieval manuscripts to laboratories, coupled with the logistical difficulties of transporting spectrometers to libraries, have restrained the rate of progress. Nevertheless, since 1989 various initiatives in London, Florence and Dublin have reported on key Insular manuscripts[2]; and a recent campaign at Durham University

[1] B. GUINEAU, « Analyse non destructive des pigments par microsonde Raman laser: exemples de l'azurite et de la malachite », *Studies in Conservation* 29, 1984, 35-41; J. VEZIN, « La microsonde Raman Laser: un nouvel instrument d'analyse des pigments dans les enluminures », *Scriptorium* 38, 1984, 325-326.

[2] Principally: M. BICCHIERI, F. P. ROMANO, L. PAPPALARDO, L. COSENTINO, M. NARDONE, and A. SODO, « Non-Destructive Analysis of the Bibbia Amiatina by XRF, PIXE- and Raman », *Quinio* 3, 2001, 169-179; R. J. H. CLARK, « Pigment identification by spectroscopic means: an arts/science interface », *Comptes Rendus Chimie* 5.1, 2002, 7-20; K. L. BROWN and R. J. H. CLARK, « The Lindisfarne Gospels and two other Eighth-Century Anglo-Saxon / Insular Manuscripts: pigment identification by Raman Microscopy », *Journal of Raman Spectroscopy* 35, 2004, 4-12; K. L. BROWN and R. J. H. CLARK, « Analysis of key Anglo-Saxon Manuscripts (8-11th centuries) in the British Library: pigment identification by Raman Microscopy », *Journal of Raman Spectroscopy* 35, 2004, 181-189; M. CLARKE, « Anglo-Saxon Manuscript Pigments », *Studies in Conservation* 49, 2004, 231-244; S.

(deploying Raman Spectroscopy, Diffuse Reflectance Spectroscopy and Hyperspectral Imaging: see **Pl. 1**) investigated a further five volumes of seventh- or eighth-century date which are of Northumbrian origin or provenance[3]. As many of the earliest Northumbrian books with significant illumination have now been examined with modern technology, including the most famous and elaborate of them (the Lindisfarne, Durham, and Cambridge-London Gospels, along with Codex Amiatinus), this is an appropriate moment to take stock of the results of these studies.

The first part of the present article surveys current knowledge about the pigments that were used in Northumbrian manuscripts, based on the recent Durham project but integrating relevant findings from the other scientific campaigns since the year 2000; the second part provides a fuller record of the work undertaken at Durham in 2013. Treated broadly in chronological order, the material begins with a seventh-century Hiberno-Northumbrian manuscript; there follow some Wearmouth-Jarrow books extending in date from the end of the seventh century into the first half of the eighth, then several volumes associated with Lindisfarne from the same period; lastly come a couple of eighth-century manuscripts that are not localised to a particular scriptorium. It is logical to begin, however, by briefly reminding ourselves of the varied cultural traditions that lay behind the earliest manuscripts of Northumbria, since this is important for contextualising the transmission of the relevant skills and ideas, and for understanding the different ways in which pigments were deployed.

BIOLETTI, R. LEAHY, J. FIELDS, B. MEEHAN and W. BLAU, « The Examination of the Book of Kells using micro-Raman Spectroscopy », *Journal of Raman Spectroscopy* 40, 2009, 430-451; L. BURGIO, S. BIOLETTI and B. MEEHAN, « Non-Destructive in situ Analysis of three early medieval manuscripts from Trinity College Library, Dublin », *Making Histories. Proceedings of the Sixth International Insular Art Conference*, ed. J. HAWKES, Donnington, 2013, 42-49.

[3] In June and October 2103, coordinated with the installation and de-installation periods for the exhibition, « Lindisfarne Gospels Durham: one amazing book, one incredible journey » (Palace Green Library, Durham, 1 July to 30 September 2013).

The first manuscripts to reach Anglo-Saxon Northumbria were probably Italian and will have arrived during the reign of King Edwin of Deira (616-633). Books were essential to the religious observances that his Christian bride, Princess Æthelburh of Kent, was guaranteed freedom to pursue[4]; and as her personal chaplain, the Italian bishop Paulinus (d. 633), was one of the Roman missionaries sent by Pope Gregory the Great, the manuscripts in question will surely have come (like Paulinus himself) via Kent from Italy. By contrast, most of the volumes that reached Northumbria during the middle third of the seventh century were from Iona and Ireland, as King Oswald (Edwin's successor from the rival Bernician dynasty) turned to the Irish community on Iona for missionaries, and established them on Lindisfarne (founded 635)[5]. Manuscripts produced locally by these men (and their Anglo-Saxon followers) will have been made in accordance with the traditions of their homeland, ties with which remained strong. In the last third of the century, however, in the aftermath of the Synod of Whitby (664), Italian volumes started reaching Northumbria again and in some numbers, above all through the endeavours of Benedict Biscop (d. 689), three of whose six visits to Rome were explicitly made to gather books (and other resources) for his monasteries of Wearmouth (founded 672/3) and Jarrow (*c.* 682)[6]. Yet notwithstanding the strength of these new links to Rome – and despite the rhetoric of those who were victorious at the Synod of Whitby - connections with Ireland were far from severed: in the eighth century, an Irish master-scribe is documented to have been practising his art at a cell of Lindisfarne, for instance[7], and a man with an Anglo-Saxon name and lineage can be found writing a

[4] Bede, *Historia ecclesiastica* II.9: *Bede's Ecclesiastical History of the English People*, ed. B. COLGRAVE and R. A. B. MYNORS, Oxford, 1969, p. 162.

[5] Bede, *Historia ecclesiastica* III.3, ed. B. COLGRAVE and R. MYNORS (supra n. 4), p. 218.

[6] In 671, 678x80 and 684-6: Bede, *Historia abbatum,* cc. 4, 6 and 9: *Abbots of Wearmouth and Jarrow*, ed. C. GROCOCK and I. N. WOOD, Oxford, 2013, pp. 30-32, 34-36, and 42-44.

[7] Ultán: Æthelwulf, *De abbatibus*, ch. 8, ed. A. CAMPBELL, Oxford, 1967, pp. 19-23.

rather Irish-looking hand[8]. Concurrently, the geography of bibliographical exchange was being enriched and complicated by new relationships with Hiberno-Saxon foundations on the Continent, such as Echternach and Fulda.

That Irish and Continental scribes had different procedures for making, writing and ornamenting manuscripts is well known; and painstaking attention to the codicology, palaeography and decoration of the limited number of surviving Northumbrian manuscripts has gradually clarified our understanding of these contrasting practices, as of their interactions. Scientific investigation of the pigments of the books provides, for the first time in decades, new data to set alongside this. What, then, have we learned about the relevant manuscripts individually, and how do these gains in knowledge contribute to our understanding of broader cultural patterns?

The Mid-Seventh Century

Durham Cathedral Library, A.II.10 (endleaves). These fragmentary leaves are the remnants of a Gospel-book or New Testament whose script (Insular Half-Uncial) and text-type (essentially Vulgate but with an Old Latin block embedded in it) suggest either that it was made in Ireland/Iona and brought to Northumbria or that it was produced in Northumbria at an Irish missionary foundation[9]. Whichever be

[8] Vatican City, Biblioteca Apostolica Vaticana, Pal. Lat. 68: E. A. LOWE, *Codices Latini Antiquiores*, 11 vols. plus *Supplement*, with second edition of vol. II, Oxford, 1934-72 [henceforth: LOWE, *CLA*], I. no. 78. The colophon on fol. 46r names the scribe as « Edilberict, son of Berictfrid »: R. GAMESON, *The Scribe Speaks? Colophons in Early English Manuscripts*, Cambridge, 2002, no. 6.

[9] Durham Cathedral Library, A.II.10, fols. 2-6 and 338-338a + C.III.13, fols. 192-5 + C.III.20, fols. 1-2: Lowe, *CLA* II, no. 147; R. A. B. MYNORS, *Durham Cathedral Manuscripts to the end of the Twelfth Century*, Oxford, 1939, no. 6, pl. 4; R. GAMESON, *Manuscript Treasures of Durham Cathedral*, London, 2010, no. 2 – with the most accurate colour plates. J.-C. HAELEWYCK, « Un Nouveau témoin vieux latin de Marc:

true, it would seem to represent the type of grand book likely to have been found in Northumbria before the influx of more cosmopolitan resources and the rise to predominance of new text-types and script styles that resulted from stronger links with the Continent after the Synod of Whitby. Accordingly, it may be tentatively dated to the mid-seventh century. Although only thirteen leaves survive, they fortuitously preserve two major examples of decoration – a large, ornamental colophon to Matthew's Gospel and a decorated incipit to that of Mark.

The predominant pigment in the colophon - used to colour the three large 'bowls' filled with knotwork - was orpiment yellow (see **Pl. 2**). The decorative interlace twists fitted into the angles between the bowls were painted with red lead orange, indigo blue, and vergaut green (a mixture of orpiment and indigo), along with more orpiment yellow. The design was animated by the application of red lead dots onto the yellow, the blue and the green, and of orpiment dots onto the red lead. The text within the bowls (the explicit to Matthew, the rubric to Mark, and the Lord's Prayer in Greek but rendered with Latin letters) was written in red lead, now faded to near-invisibility. When new and undecayed, the effect would have been vivid; however, degradation of the dots and the fading of the red script have enervated this.

The same four pigments – red lead, indigo, orpiment, and vergaut – along with black ink were used in the Incipit to Mark (see **Pl. 3**). Orpiment and occasionally vergaut, outlined with red lead dots or lines, were, in addition, deployed throughout the text (which is set out in long lines) to give extra emphasis to the enlarged initials that mark Eusebian sections. Once (in the pages that survive) red lead and orpiment were used on an even footing, colouring different areas of the same letter, thereby flagging Matthew 27.38, the account of the Crucifixion[10]. The ink used both for the text and in the artwork

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Le MS. Durham Cathedral Library, A.II.10+C.III.13+C.III.20 », *Revue bénédictine* 122, 2012, 5-12, highlights the Old Latin block at Mark 2.12b-6.5.

[10] Fol. 3r: R. GAMESON, *Manuscript Treasures* (supra n. 9), p. 27.

remains a rich dark black; investigation by infra-red imaging suggests that it is likely to be based on iron gall rather than carbon.

The red lead in this manuscript displays a granular surface texture and appears less even than that in the other examples examined by the Durham team. The indigo was applied thickly; the vergaut (a relatively sombre green) rather less so[11]. In the incipit initial as in the colophon, lines of dots in a second colour were applied over the blocks of paint to enliven their contours – with the result that red lead was often placed onto orpiment. It is well established that the adverse reaction between these substances (lead (II, IV) oxide and arsenic (III) sulfide) may cause the red to darken, as has happened in the colophon[12]. In the initial, however, the degradation is far less obvious. One possible explanation for this anomaly, albeit impossible to verify at present, is that the orpiment here may have been covered with a layer of glaze before the red was applied, effectively insulating the one from the other.

Wearmouth-Jarrow

[11] In contrast to the former, it displayed no plateaux of glaze with canyons of cracks, when viewed under the microscope.

[12] The degradation of lead-based pigments has been well documented. The process assumed to occur is the reaction of lead white or lead oxides with sulfur-containing materials – which include orpiment (arsenic (III) sulfide) – to yield the metallic/black lead sulfide known as galena. This reaction has been studied in some detail (C. MIGUEL, A. CLARO, A. P. GONÇALVES, V. S. F. MURALHA and M. J. MELO, « A Study on red lead degradation in a medieval manuscript, Lorvão Apocalypse (1189) », *Journal of Raman Spectroscopy* 40, 2009, 1966-1973, and its features will be familiar to conservators. However, based upon our observation of the survival of some red lead painted onto orpiment (in DCL A.II.10 and ?the Lindisfarne Gospels), there is evidence that the process is by no means inevitable. One may speculate that some scribes, aware of the potential reaction, were able to mitigate it by some means – possibly by the use of barrier layers of glaze.

Durham Cathedral Library, B.IV.6, fol. 169.* Little more than half a leaf survives of this sixth-century Italian copy of the Book of Maccabees which is written in Uncial and set out *per cola et commata* (i.e. with a new line for each sense unit)[13]. Nevertheless, unique correspondences between its text and that of the relevant portion of Codex Amiatinus (one of the three pandects made at Wearmouth-Jarrow between 689 and 716) leave little doubt that this is the remains of a volume acquired by Benedict Biscop (or his followers) on one of his journeys to Rome. Ornamentation is limited to a small penwork initial in the form of a fish; and there is no pigment, only ink**.** No Raman spectra could be obtained from the page; however, infra-red imaging suggested that the ink, though strikingly different in appearance from that of the previous, Hiberno-Northumbrian manuscript - brown and matt rather than black and slightly glossy - was also based on iron gall.

Durham Cathedral Library, A.II.17 (part 2) is the remains of a high-status gospel-book which, its Uncial scripts indicate, was made at Wearmouth-Jarrow but which, additions show, passed at an early date to the Community of St Cuthbert; it may have served as the textual exemplar for the Lindisfarne Gospels[14].

[13] LOWE, *CLA* II, no. 153; R. MYNORS, *Durham Cathedral Manuscripts* (supra n. 9), no. 1, pl. 1; E. A. LOWE, « A Sixth-Century Italian Uncial Fragment of Maccabees and its Eighth-Century Northumbrian Copy », *Scriptorium* 16, 1962, 84-85; R. GAMESON, *Manuscript Treasures* (supra n. 9), no. 1.

[14] Fols. 103r-111v: LOWE, *CLA* II, no. 150; R. MYNORS, *Durham Cathedral Manuscripts* (supra n. 9), no. 3, pl. 2; R. GAMESON, *Manuscript Treasures* (supra n. 9), no. 3. Black and white facsimile: *The Durham Gospels*, ed. C. VEREY, T. J. BROWN and E. COATSWORTH (Early English Manuscripts in Facsimile 20), Copenhagen, 1980. In this rare instance where parchment from Wearmouth-Jarrow is directly juxtaposed with that made at ?Lindisfarne (Part I of the same book), the former is perceptibly more translucent than the latter.

The details of the script and the minimal word separation point to a date of production at the very end of the seventh century or around 700[15].

The surviving leaves preserve no decoration, and the only pigment to appear is the red lead that was used for the Eusebian apparatus in the margins and for the first letter of the single surviving capitulum division. Yet if the use of Uncial and the arrangement of the text *per cola et comata* with minimal word division show an unmistakable debt to Italian example (reflecting Wearmouth-Jarrow's direct connections with Rome, not to mention the presence in the twin community of Italian teachers[16]), the dark black ink in which it is written is more akin to that of the Hiberno-Northumbrian, DCL, A.II.10 than to the lighter brown ink of the Italian Maccabees leaf.

The leaves from a second Wearmouth-Jarrow gospel-book written in Uncial, which probably dates from the early eighth century and which has ended up in Utrecht, fortuitously include a general title page and the incipits to both Matthew and John[17]. Although these have not yet been analysed scientifically (so far as we can ascertain), they nonetheless still valuably reveal the restrained nature of the decorated pages in a high-grade gospel-book made at this twin monastery. The bold legend of the title page, written in rich black ink, is set within a coloured circle filled with intersecting bands of yellow, green and blue (all fairly pale tones). The incipits were modestly accentuated by leaf gold - used for the entire first word of Matthew's Gospel, merely for the initial letter of that of St John. Red was deployed

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[15] The chronology of Wearmouth-Jarrow books is re-examined by R. GAMESON, « Materials, Text, Layout and Script » in *The St Cuthbert Gospel*, ed. C. BREAY and B. MEEHAN, London, 2015, 15-39, esp. pp. 27-33.

[16] Documented by Bede, *Homelia in natale S. Benedicti*, c. 12, and Anon., *Vita Ceolfridi*, c. 9: *Abbots of Wearmouth and Jarrow*, ed. C. GROCOCK and I. WOOD (supra n. 6), pp. 16 and 88.

[17] Utrecht, Univesiteitsbibliotheek, 32, fols. 94-105: LOWE, *CLA* X, no. 1587. Colour facsimile: *Utrecht-Psalter*, ed. K. VAN DER HORST and J. ENGLEBREGT, 2 vols., Graz, 1984.

for rubrics and for the first letters of capitulum sections (and not only within the gospel text itself, but also in the list of capitula included in the preliminaries). Given the fragmentary state of the manuscript, it is impossible to be certain whether or not it originally included evangelist portraits wherein more colours might have been deployed; however, the start of Matthew, which is seemingly intact, has no lacuna between the general title and the gospel incipit[18], and as most late Antique gospel-books (like Carolingian ones after them) did not have portraits, it seems likely that the same was true here too.

Certainly, there is no pictorial decoration in the *Cuthbert Gospel of John*, also from Wearmouth-Jarrow, probably made in the early eighth century, and as this manuscript is still in its first binding with an undisturbed, regular quire structure, the fact that it is intact is beyond question[19]. Its text is presented in accordance with the principles seen in the two gospel-books. One or more red letters were deployed to mark the start of capitula[20]; there was no other ornamentation or colour[21]. As in the two Wearmouth-Jarrow gospel-books, the text was set out *per cola et commata*.

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[18] The quire in question is a quaternion, formed from three bifolia and two singletons (these being the second and seventh folios). The title page is the verso of the fifth folio, the incipit is the recto of the sixth: both thus appear on the second halves of neighbouring, intact bifolia. The structure does not, therefore, favour the former presence of a portrait, which would have had to have been inserted on an extra singleton (of which there is no visible trace) between leaves five and six - making the quire an irregular '9'. For further details of the structure of this quire see *Utrecht-Psalter*, ed. K. VAN DER HORST and J. ENGLEBREGT (supra n. 17), II (*Kommentar*), p. 49.

[19] London, British Library, Add. 89,000. Black and white facsimile: *The Stonyhurst Gospel of Saint John*, ed. T. J. BROWN, Roxburghe Club, Oxford, 1969.

[20] The manuscript is currently the subject of technical investigation.

[21] Since this is a single gospel, not a gospel-book, there is no marginal apparatus of correspondences, as found in the Wearmouth-Jarrow gospel-books.

The only extant miniatures (hardly an appropriate term given their grand scale) that are associable with Wearmouth-Jarrow appear in *Codex Amiatinus*, the pandect datable to between 689 and 716[22]. Notwithstanding debates over the precise meaning of the image that prefaces the Old Testament featuring the Jewish priest Ezra in the role of a scribe, there is no doubt that it was informed by close study of a late Antique exemplar[23]. What is particularly relevant in the present context is the fact that the need to attempt modelling of form via shading required the artist to use different hues within a given colour. The phenomenon is particularly noticeable on the *armarium* that dominates the back of the composition: more sombre tones contribute to the illusion that its side and interior recede into the picture plane, while darker and lighter lines define panels inset into its doors. Similarly on the *Maiestas* page that precedes the New Testament, different hues of green, grey and blue, along with white

[22] Florence, Biblioteca Medicea-Laurenziana, Amiatino 1: LOWE, *CLA* III, no. 299; L. ALIDORI, L. BENASSAI, L. CASTALDI, M. CECCANTI, E. FUSI, E. MATTIA and S. NENCIONI, *Bibbie Miniate della Biblioteca Medicea Laurenziana di Firenze*, Florence, 2003, pp. 3-58. M. BICCHIERI *et al.*, « Non-destructive analysis of Bibbia Amiatina » (supra n. 2), report the application of Raman spectroscopy, XRF, and PIXE-□ to the codex, examining pigment offsets on adjacent pages in the contentious first quire in the hope of shedding light on the order of the leaves; there is ambiguity in the account of their findings in that the nature of the blue pigment was not identified and that the greens were reported to be mixtures of blue and orpiment or copper-based pigments.

[23] Fol. Vr. Colour plates (of uncertain quality): *Codex Lindisfarnensis*, ed. T. J. BROWN, R. L. S. BRUCE-MITFORD, A. S. C. ROSS and E. G. STANLEY, 2 vols., Olten and Lausanne, 1956-60, II, pl. 21; K. WEITZMANN, *Late Antique and Early Christian Book Illumination*, New York, 1977, pl. 48.

highlights, were used to suggest that the decorative band encircling Christ and his attendant angels undulates towards and away from the beholder[24].

Correspondingly, the palette of Codex Amiatinus was more extensive than those of the volumes examined hitherto, with several pigments or mixtures deployed to achieve a range of tones within a given colour. Thus for red colours, organic lakes and earths were used in addition to red lead; as well as orpiment, organic lakes and earths were deployed for yellows; and both vergaut and verdigris (with an admixture of an unidentified organic compound) appear for green. In addition there were whites (calcite and white lead), browns (earth colours - irons and copper - often mixed with orpiment or gold) and greys (generally formed from one of the whites mixed with blue and carbon black, though silicates containing copper and iron were also deployed) along with metallic inks (which displayed a variable composition of copper, lead, silver and gold, sometimes with admixtures of orpiment or iron earths).

Lindisfarne

Durham Cathedral Library, A.II.17 (part 1), the so-called *Durham Gospels*, is generally attributed on the grounds of its script (Half-Uncial) and provenance (the Community of St Cuthbert) to Lindisfarne (see **Pl. 4**)[25]. Notwithstanding extensive loss of leaves and other damage over the centuries, it remains a magnificent book. It has been seen as representing the work of a scriptorium on Lindisfarne after the revivification of that community in the 680s but before the availability there of – or prior to the wish to

[24] Fol. 796v. Colour plates: *Codex Lindisfarnensis,* ed. T. BROWN *et al* . (supra n. 23), II, p. 24; L. WEBSTER and J. BACKHOUSE (ed.), *The Making of England: Anglo-Saxon Art and Culture AD 600-900*, London, 1991, p. 124; and L. ALIDORI *et al*., *Bibbie Miniate* (supra n. 22), pl. II.

[25] LOWE, *CLA* II, no. 149; R. MYNORS, *Durham Cathedral Manuscripts* (supra n. 9), no. 4, with colour frontispiece of a reasonable fidelity; *Durham Gospels*, ed. C. VEREY *et al.* (whose colour plates are of poor fidelity); R. GAMESON, *Manuscript Treasures* (supra n. 9), no. 4 (with the most accurate colour reproductions).

respond to - new text-types and models from Italy, made available via Wearmouth-Jarrow. Assuming that this is broadly correct, the manuscript may be ascribed to the end of the seventh century.

From the perspective of pigment analysis, it is extremely unfortunate that the one remaining miniature in the book (depicting the Crucifixion) is in a very poor condition, having suffered extensive surface damage, its colours being dulled: consequently, obtaining usable spectra from it proved difficult[26]. The only materials positively identified were red lead, massicot (a lead monoxide) and orpiment. An extremely faded area that may once have been blue did not provide meaningful spectra – so it was not possible to confirm or deny the presence of a blue matter, let alone identify it; no blue appears elsewhere in the manuscript.

The palette used for the decorated initials (both the one surviving major incipit – that to John's Gospel[27] – and the enhanced letters and polygrams marking capitulum divisions and Eusebian sections) comprised red, yellow, green and purple. The red and yellow were unequivocally identified as red lead and orpiment respectively. Raman analysis of the green areas using a red laser (633 nm) gave no spectra to indicate the use of vergaut (under these conditions the Raman spectrum of orpiment is particularly strong and distinctive, hence this pigment itself and vergaut – of which it is a component – can reasonably be eliminated). Diffuse reflectance and NIR imaging revealed that the green areas were strongly absorbing in the NIR region, a characteristic of copper-based pigments. Using a green laser (532 nm), some bands could be observed from the green areas at *c.* 2900 cm-1, resembling what others

[26] Fol. 38(3)v. Colour reproduction (enhanced to be clearer and brighter than the original): C. NORDENFALK, *Celtic and Anglo-Saxon Painting*, New York, 1977, pl. 14. Probably as a consequence of having been reused for part of its life as a pastedown (in Durham Cathedral Library, A.II.22: see further *Durham Gospels*, ed. C. VEREY *et al.* (supra n. 14), pp. 64-5), the page is covered with a dark layer of ?glue residue, obscuring the paint that survives. Despite this contamination, it was still possible to obtain spectra by lowering the focal point of the laser beam to a few micrometres below its surface.

[27] Fol. 1r. Most accurate colour plate: R GAMESON, *Manuscript Treasures* (supra n. 9), p. 31.

have characterised as verdigris[28]. Thus, although the exact composition of the green pigments could not be established, it may reasonably be referred to as « verdigris » (as is done by others in the field), while recognising its diverse character. The nature of the purple was impossible to diagnose by Raman microscopy: an organic substance, it is probably orcein (from lichen) or conceivably the dye obtainable from the British 'dog whelk', *nucella lapillus*, whose rich tones Bede celebrated[29]. It is notable that the palette of this manuscript differs appreciably from that of the mid-seventh-century Hiberno-Northumbrian volume, DCL A.II.10, in not using blue (at least in the text pages) but including purple, and in deploying copper-based green pigments rather than vergaut.

The colours were generally applied individually. The exceptions were certain initials within the body of the text marking Eusebian sections, where red lead dots were superimposed on a black letter shape or orpiment ones onto an area of purple. In contrast to the red lead plus orpiment seen in DCL A.II.10, neither of the combinations used in the Durham Gospels showed signs of degradation[30].

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[28] K. BROWN and R. CLARK, « Lindisfarne Gospels » (supra n. 2); P. RICCIARDI, A. PALLIPURATH and K. ROSE, « It's Not Easy Being Green: a spectroscopic study of green pigments used in illuminated manuscripts », *Analytical Methods* 5, 2013, 3819-3824.

[29] *Historia ecclesiastica*, I.1, ed. B. COLGRAVE and R. MYNORS (supra n. 4), p. 15. For general comment on the use of purple colour-stuffs in England see G. HENDERSON, *Vision and Image in Early Christian England*, Cambridge, 1999, pp. 122-35, and C. P. BIGGAM, « Knowledge of whelk dyes and pigments in Anglo-Saxon England », *Anglo-Saxon England* 35, 2006, 23-55. The one scientific investigation (reported by Biggam) devoted to identifying the purples in early medieval manuscripts (based on the presence in whelk dyes of bromine which can be detected by X-ray fluorescence) found « Tyrian Purple » in but one small area of a single book (the Barberini Gospels: Vatican City, Biblioteca Apostolica Vaticana, Barberini lat. 570).

[30] Examples on fols. 14r, 14v, 17v, 18v, 19v, 20r, 23r, 36v, etc.

The *Lindisfarne Gospels*, credibly attributed to Holy Island and datable to around 700 or the very beginning of the eighth century, survives intact with a full decorative programme of canon tables, evangelist portraits, carpet pages and full-page gospel incipits, all in an excellent state of preservation[31]. Raman analysis of the major decorated pages revealed a palette that comprised lead red , orpiment yellow, and indigo blue, both vergaut and verdigris greens, iron-gall black (sometimes with admixtures of carbon), pinks that could include white lead or chalk, plus a range of organic dye-stuffs for certain yellows, pinks, and purples, along with metallic gold[32]. This is, by the standards of the day, a rich selection, significantly more varied than that of the Durham Gospels (though it must be remembered that that manuscript has lost almost all its major decorated pages), and one that is rivalled or exceeded only by that of Codex Amiatinus.

Cambridge, Corpus Christi College, 197B. Affiliated to the Durham and Lindisfarne Gospels by its script and decoration, and to the Durham Gospels (again) by its text-type, the so-called *Cambridge-London Gospels*

[31] London, British Library, Cotton Nero D. iv. A later date is advocated by M. P. BROWN, *The Lindisfarne Gospels and the Early Medieval World*, London, 2011, pp. 65, 92 and elsewhere (as also in her earlier, *The Lindisfarne Gospels: society, spirituality and the scribe*, London, 2003). Some of the difficulties with this hypothesis are outlined in R. GAMESON, *From Holy Island to Durham: the contexts and meanings of the Lindisfarne Gospels*, London, 2013, esp. pp. 16-19 and 30-31 with 147 n. 33, where the case is put for *c.* 710 as a more realistic upper limit.

[32] K. BROWN and R. CLARK, « Lindisfarne Gospels and other eighth-century Anglo-Saxon/Insular Manuscripts » (supra n. 2). The most faithful colour reproductions are those of the facsimile, *Das Buch von Lindisfarne/The Lindisfarne Gospels*, ed. M. P. BROWN, Luzerne, 2003; the next most accurate are those in R. GAMESON, *From Holy Island to Durham* (supra n. 31), which were colour-corrected against the manuscript itself.

was probably produced at Lindisfarne or its milieu in the early eighth century (see **Pl. 5**)[33]. Though a handsome volume in its own terms, it was more modest than the Durham and Lindisfarne Gospels both in size and in decorative conception. The tragic destruction of almost all of the London portion in the Cotton Library fire of 1731 leaves only the Cambridge section available for first-hand analysis.

The palette of its two surviving major decorated pages was restricted to four pigments – identified by Raman spectroscopy and NIR-imaging as orpiment, red lead, a copper-based green (verdigris), and an organic purple dye which was fluorescent – plus black ink (iron gall)[34]. The same colours were used on the enlarged initials that highlight Eusebian sections within the text[35]. On the incipit page, the red lead was accompanied by massicot, a lead monoxide resulting from incomplete roasting during the manufacturing process. Traces of massicot were also found in the red lead on fol. 10r, but nowhere else. This shows unequivocally that different batches of the ink were used in the production of this manuscript.

It will be noted that the range of pigments in the Cambridge-London Gospels is identical to that deployed in the Durham Gospels. Generally the colours were applied individually and were kept discreetly separate; however, on the head of St John's symbol, the eagle, raised dots of orpiment were

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[33] Cambridge, Corpus Christi College, 197B + London, British Library Cotton Otho C.v + Royal 7 C. xii, fols. 2-3: LOWE, *CLA* II, no. 125; M. BUDNY, *Insular, Anglo-Saxon and Early Anglo-Norman Manuscript Art at Corpus Christi College, Cambridge*, 2 vols., Kalamazoo, 1997, I, no. 3; II, col. pls. II-III. For reproductions of the London leaves see G. HENDERSON, *From Durrow to Kells. The Insular Gospel-Books, 650-800*, London, 1987, ills. 94-96 and 112; and L. WEBSTER and J. BACKHOUSE (ed.), *Making of England* (supra n. 24), p. 117.

[34] Fols. 1r and 2r. Best available colour reproductions: L. WEBSTER and J. BACKHOUSE (ed.), *Making of England* (supra n. 24), p. 118; GAMESON, *From Holy Island to Durham* (supra n. 31), ill. 31 (p. 54).

[35] Good colour reproductions of fols. 2v and 16r: R. GAMESON, *From Holy Island to Durham* (supra n. 31), ills. 81-234.

applied to the painted purple ground, creating a striking stippled effect. The deployment of orpiment onto an organic purple – an inert combination – was also anticipated in the Durham Gospels, it will be recalled. The treatment of the wing, breast and neck of John's eagle, with individual feathers being coloured green, red or yellow, and separated from their neighbours by outlines of ink plus tiny reserved zones of virgin parchment, is closely similar to the approach followed for the feathery seraphim in the Crucifixion miniature of the Durham Gospels - another parity between these two books[36]. By extension, the Cambridge-London eagle provides a useful indication of how vividly colourful will have been the Durham Crucifixion miniature in its original state.

The *Royal-Athelstan Gospels*, intimately linked to the Lindisfarne Gospels by its gospel text (which was copied directly or indirectly from the same 'Italo-Northumbrian' exemplar), was probably produced on Holy Island at some point during the first half of the eighth century[37]. It was a more economical production than the volumes considered hitherto, having no miniatures, very modest gospel incipits, and canon tables whose columns and arcades were rendered with single ink lines. Correspondingly, a limited range of colour was deployed sparingly within the artwork, merely gracing certain areas of the initials and selected small motifs within the canon table arcades[38]. Throughout the text, however, red was deployed

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[36] The same approach was used in the Book of Durrow (Dublin, Trinity College, 57: LOWE, *CLA* II, no. 273).

[37] London, British Library, Royal 1 B. vii: LOWE, *CLA* II, no. 213; S. MCKENDRICK, J. LOWDEN and K. DOYLE (ed.), *Royal Manuscripts. The Genius of Illumination*, London, 2011, no. 1.

[38] Colour plates: S. MCKENDRICK and K. DOYLE, *Bible Manuscripts. 1400 Years of Scribes and Scripture,* London, 2007, no. 14, p. 27 (showing fol. 55r); S. MCKENDRICK *et al.* (ed.), *Royal Manuscripts* (supra n. 37), pp. 96 and 97 (fols. 84v and 15v); M. BROWN, *Lindisfarne Gospels and the Early Medieval World* (supra n. 31), ills. 33-4 (10v, 15v); R. GAMESON, *From Holy Island to Durham* (supra n. 31), ill. 177 (130v).

fairly extensively: the entire first lines of capitulum divisions were written in red, the black initials for Eusebian sections were outlined with red dots, and red initials head each entry in the capitula lists and the lection lists. The three pigments deployed in the book were orpiment, vergaut, and red lead. The fact that no blue was used in its own right is worthy of note for, since the vergaut green was created from a mixture of orpiment and indigo, it is evident that blue must have been available in the scriptorium. This, therefore, is a rare case where we can be confident that the absence of a colour was the result of deliberate choice rather than simply being a side-effect of a lack of relevant materials.

Non-localised Eighth-Century Volumes

Durham Cathedral Library, A.II.16 is an enigmatic Northumbrian gospel-book (see **Pl. 6**). Beyond the fact that it is from Northumbria (as script, text and ornament indicate), its early history is obscure[39]. The first available evidence for its provenance dates from the twelfth century (when it belonged to Durham Cathedral priory). The manuscript was the work of four scribes with contrasting hands: the first (who wrote in Uncial) accomplished the first two-thirds of both Matthew and Mark; the second (who used Insular Half-Uncial) contributed the end of Matthew and the second half of Luke; the third (another practitioner of Uncial) did the end of Mark and the first half of Luke; while the fourth (a second exponent of Insular Half-Uncial) was responsible for John. With four hands using two different scripts and each, as it happens, following a different text-type, the manuscript has sometimes been seen as a composite volume; however, there is evidence to suggest that the Synoptic Gospels were in fact produced as a single operation in one centre. Whether John, too, was made in the same place around the same time is an open question, but it is not impossible. Whatever the answer, the Synoptics were evidently – and the whole manuscript possibly - the product of a team based at a centre where scribes

[39] LOWE, *CLA* II, no. 148a-c; R. MYNORS, *Durham Cathedral Manuscripts* (supra n. 9), no. 7, pls. 5-7; R. GAMESON, *Manuscript Treasures* (supra n. 9), no. 6.

trained in different traditions worked side by side, and whose members were apparently transcribing simultaneously from different exemplars.

The only surviving major decoration is the incipit initial to Mark's Gospel (within the stint of scribe one)[40]. The colours visible here are a pale yellow and a rich orange (partly now discoloured), along with black. The yellow offered no meaningful Raman spectra: whilst not identifying the pigment, this negative result effectively rules out orpiment, from which one invariably obtains a strong Raman signal. Plant dyes were suspected to have been used for some of the yellow areas in the Lindisfarne Gospels, and this was probably the case here too. Whatever the identity of the yellow matter in DCL A.II.16, it was certainly used very sparingly – there is more binding medium than pigment in this particular paint. The orange (deployed for the main body of the dragonesque head at the bottom of the initial as well as in the continuation capitals) was identifiable as red lead. The fact that it was red lead alone is worth stressing, for the orange-red that was used in the marginal apparatus was found, by contrast, to be a mixture of red lead and massicot. Indeed some of the spectra recorded in this area were those of pure massicot, indicating a high proportion of this lead oxide in the ink. The distinction between the composition of the two oranges indicates that different batches of ink were used on the same page (a phenomenon also seen in the Cambridge-London Gospels it will be remembered). In John's Gospel alone (the stint of scribe four) the enhanced initials are filled with yellow – identifiable as orpiment[41]. If this, then, is an aspect of production that distinguishes John from the Synoptics, it is nevertheless linked to them by the composition of the red dots that outline the initials, for here as there the pigment was a mixture of red lead and massicot. Overall, the palette of this book sets it a little apart from the other manuscripts we have examined, just as its combination of Uncial and Insular Half-Uncial scripts distances it from other Northumbrian scriptural manuscripts more generally.

[40] Fol. 37r. Colour plate: R. GAMESON, *Manuscript Treasures* (supra n. 9), p. 39.

[41] Colour plates: R. GAMESON, *Manuscript Treasures* (supra n. 9), p. 41; GAMESON, *From Holy Island to Durham* (supra n. 31), ill. 73.

Durham Cathedral Library, B.II.30. The oldest surviving copy of Cassiodorus's Commentary on the Psalms, albeit in an abbreviated version, the *Durham Cassiodorus* was the work of a team of scribes who wrote varieties of formal (or 'set') Insular minuscule[42]. Full-page miniatures of David in different guises preface Psalms 51 and 101, and there was doubtless once a third such image before Psalm 1 (the circumstance that the beginning of the book was restored in the twelfth century suggests that this may already have been lost or damaged by then). The origin of the manuscript is debated. The best case that can be made, albeit entirely on circumstantial grounds, is for York. Without a specific context, it is difficult to date the volume more precisely than to the eighth century in general.

The colours observable in the two miniatures (the second of which is badly faded) are orange, green, purple, and a pale yellow[43]. Orange was also used within the text for headings, for parts of the quotations from the psalms, and for outlining some of the enlarged ink initials and the continuation lettering that introduce sub-sections[44]. In the miniatures and text alike, Raman spectroscopy revealed that the orange was red lead. In some areas, red lead alone was found, while in others traces of massicot were detected. As before, this hints at different batches of pigment being employed or even at the work being accomplished in distinct stages. NIR-imaging and diffuse reflectance spectroscopy established that the green was a copper-based pigment. Neither the faded purple nor the yellow provided Raman spectra. This is typical of organic purples. In relation to yellow, it is altogether less common and suggests the use of an organic pigment or glaze, rather than orpiment. It will be noted that the absence of orpiment and the use of an alternative form of yellow is something that the manuscript has in common with the previous item, the gospel-book DCL, A.II.16.

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[42] LOWE, *CLA*, II, no. 152; R. MYNORS, *Durham Cathedral Manuscripts* (supra n. 9), no. 9, pls. 8-10; R. GAMESON, *Manuscript Treasures* (supra n. 9), no. 5.

[43] Fols. 81v, 172v. Colour plates: R. GAMESON, *Manuscript Treasures* (supra n. 9), pp. 34 and 36.

[44] *Ibid.*, p. 37.

General Observations

Considering the material as a whole, three areas in particular merit further comment. The first concerns the range of colours in general. The only truly ubiquitous pigment was red lead (be it with or without massicot, according to the degree of roasting of the lead-oxides during the manufacturing process). The group that appears sufficiently regularly to be described as 'common' comprises red, green and yellow, plus black ink and 'white' parchment (this was also the palette of the Book of Durrow, incidentally[45]) and even here there were alternatives that might be used for yellow and green – respectively orpiment or an organic material, and vergaut or verdigris. It is striking that one of the three pigments on which Northumbrian (and other early medieval) scribes relied – orpiment – was apparently only obtainable through long-distance trade[46]. The use of organic dyes stuffs for yellow where one would have expected orpiment in the Synoptic Gospels of DCL A.II.16 might then reflect not a different origin from the John portion of the book (in which orpiment does appear) but rather production at a different moment in time – when stocks of the mineral were temporarily exhausted. And while this could imply a disjunction of some years, it need not mean a gap any longer than the brief moment it would have taken

[45] See note 36. Identification of pigments: L. BURGIO *et al.*, « Three Early Medieval Manuscripts from Trinity College Library » (supra n. 2); we are grateful to Bernard Meehan for having supplied us with a copy of this important study in advance of publication. Colour plates: B. MEEHAN, *The Book of Durrow. A Medieval Masterpiece at Trinity College, Dublin*, Dublin, 1996.

[46] The very limited deposits in Britain (see A. G. TINDLE, *Minerals of Britain and Ireland*, Harpenden, 2008, pp. 373-4), not to mention the lack of any tradition of mining them, effectively rule out a local source; we are grateful to Brian Young for advice on this point. Although there are significant deposits elsewhere in Europe (for instance, Italy), D. V. THOMSON, *The Materials of Medieval Painting*, London, 1936, pp. 176-7, claimed that the supplies used in medieval Europe in general were imported, « chiefly from Asia Minor » - albeit without citing any specific evidence.

one scribe to use up the final drop of the last batch of paint made from the orpiment that was to hand. Although relatively small amounts of the pigment would suffice to colour a very large number of decorated initials, supplies must sometimes have been irregular, and supply-chains occasionally interrupted, given the uncertainties of travel across Europe and beyond in the seventh and eighth centuries. One may further note that, while realgar and pararealgar are often found alongside deposits of orpiment, they are almost unknown in the pigments examined by the Durham team[47]. This suggests that careful screening of the minerals took place probably in the scriptorium as well as at the source of supply.

If other colours were to be added to the triad of red, yellow and green, the next would be either indigo blue, as was seen in DCL A.II.10 (as also the Irish Book of Armagh[48]) or an organic purple, as featured in the Durham Gospels. It is curious that these were not more common, given that their sources (woad and lichen respectively) were (unlike orpiment) readily available locally and that the dye was relatively easy to extract. As, moreover, indigo was comparatively simple to store, its absence is unlikely to have been because supplies were unobtainable at key moments during the preparation of the manuscripts in question. Now it will be remembered that in at least one case (the Royal-Athelstan Gospels), the absence of blue was demonstrably a deliberate choice - since the vergaut green used therein was a mixture of orpiment and indigo. One is entitled to wonder, therefore, whether the restrained use of blue and purple may have been a matter of aesthetic preference. Might it even have been precisely because the source materials in question were relatively ubiquitous and thus perceived as less precious? While there are insufficient data to resolve the matter, such indications as we have would seem to point in this direction.

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[47] The single example in the manuscripts examined by the Durham team was a tiny speck of pararealgar amidst the red lead on fol. 2r of DCL A.II.10: see further the account of that page under *Results* below.

[48] Dublin, Trinity College, 52: LOWE, *CLA* II, no. 270. Pigments: L. BURGIO *et al.*, « Three Early Medieval Manuscripts from Trinity College Library » (supra n. 2).

Only in two cases from Northumbria, namely the Lindisfarne Gospels and Codex Amiatinus, was a significantly wider range of materials deployed - other organic dyes, brown earths, chalk, plus white lead, and precious metals – in order to achieve an appreciably more varied palette. This situation is paralleled in the early Irish corpus, where but one manuscript (the Book of Kells) displays a broader range of pigments (various organic dyes and coloured glazes in addition to the aforementioned « staples »)[49]. Other comparably rich volumes (and individual pages) which have not come down to us were doubtless produced both in Northumbria and in Ireland[50]; however, the fact that the Lindisfarne Gospels, Codex Amiatinus, and the Book of Kells - along with any lost counterparts of a similar grade - were exceptional in their contexts is hardly in question.

The second general point concerns the manner in which the colours were normally deployed. In most books they were applied individually, areas of one pigment being juxtaposed with, rather than blending into, another. Indeed they would often be separated one from another by tiny reserved areas of blank parchment or by ink lines, or indeed by both – requiring meticulous pen control to achieve. The many minor initials in which one segment is yellow, the other green, the two zones being separated by black ink and « white » parchment, the whole being outlined (at a discreet distance) with red dots, typify the « separationist » approach in question. This was arguably both a practical expedient (a precaution for avoiding adverse chemical reactions that might arise from the contact of different substances), and an aesthetic choice – affording maximum chromatic impact to each colour. In DCL A.II.10, dots of one colour were superimposed onto another, often red lead onto orpiment, as we have

[49] Dublin, Trinity College, 58: LOWE, *CLA* II, no. 274; S. BIOLETTI *et al.*, « Examination of Book of Kells » (supra n. 2); B. MEEHAN, *The Book of Kells*, London, 2012, with discussion of pigments at pp. 224-33.

[50] The obvious example is the « Book of Kildare », described in the later twelfth century by Gerald of Wales, *Topographia Hibernica*, c. 38: *Giraldi Cambrensis Opera*, ed. J. S. BREWER, J. F. DIMOCK and G. F. WARNER, 8 vols. (Rolls Series), London, 1861-91, vol. V, pp. 123-4.

seen – and they have sometimes degraded as a result. Now, this is the earliest manuscript in our corpus and, although over-painting of red lead and orpiment was not entirely avoided thereafter (there are small examples scattered throughout the Lindisfarne Gospels, for example[51]), one might still hypothesise that the observable deterioration of these colours placed in contact with each other in mid-seventh-century books encouraged artists of subsequent generations to be more circumspect in how they applied their paint-stuffs. In the Durham and Cambridge-London Gospels, it will be noted, such over-painting as appears was of red lead onto black ink or of orpiment onto an organic purple – stable combinations. Interestingly, the presumed red lead applied to orpiment in the Lindisfarne Gospels does not appear to have degraded very much: the most obvious explanation would be that the two pigments were actually separated by an insulating layer of glaze; however, until the phenomenon has been investigated properly, this is but a hypothesis.

The essential vocabulary of Insular illumination – with numerous sections of abstract or semi-abstract ornament in repeating and mirror-image patterns, complementary elements being picked out in contrasting colours – was ideally suited to the 'separationist' approach summarised above. Not so, however, the subtle tonal gradations and shading that were essential for « naturalistic » art, for these inevitably diminished the purity and luminescence of the individual colours, not to mention requiring different pigments to be mixed and superimposed. The image of Ezra in Codex Amiatinus with its attempts at modelling and shading is a rare case of a Northumbrian artist attempting a semi-naturalistic

[51] A cluster of red dots (often three but sometimes more) was intermittently applied to the coloured areas (most frequently yellow, occasionally green, exceptionally purple or blue) of the initials marking Eusebian sections and capitulum divisions throughout the book. Red dots also appear on the alternately green and yellow grounds of the initials for the Beatitudes on 34r. In addition, they were applied to a yellow ground within the continuation lettering of *Nouum opus* (3r), and to yellow, blue and purple grounds within that of *Quoniam quidem* (139r).

aesthetic. Now Codex Amiatinus had an exceptionally wide palette and one rich in organic substances. It is a nice question, then, how far this may have been a direct result of the wish to imitate the chromatic range of a naturalistic model and how far an indirect result of that same wish: for if one were going to indulge in mixing and over-painting, it may have been felt prudent to turn to additional substances that were known or presumed to be inert when combined with others. Certainly, one of the earliest medieval treatises on pigments to have come down to us (albeit a little later in date than the period that concerns us here) warns about the incompatibility of certain substances including orpiment and red lead[52].

The evangelist portraits in the Lindisfarne Gospels, by contrast, show a contemporary hand reinterpreting a naturalistic model in terms of colour contrasts and juxtapositions. Folds in drapery, to take a single motif, are depicted not by darker or lighter hues of the cloth's core colour nor by an over-painting of certain areas in brown, black or white, but rather by lines of an entirely different colour. Thus the fold-lines within St Matthew's green over-mantle are a boldly contrasting red; the folds in Mark's purple over-mantle are blue, while those in his blue under-robe are red[53]. It has recently been

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[52] *De coloribus et mixtionibus*, cc. ix-xi: *Mappae Clavicula. A little key to the World of Medieval Technology*, ed. C. S. SMITH and J. G. HAWTHORNE (Transactions of the American Philosophical Society, new series 64/4), Philadelphia, 1975, pp. 27-8. The underlying compilation is thought to date from *c.* 800: see M. CLARKE, *The Art of All Colours. Mediaeval Recipe Books for Painters and Illuminators*, London, 2001, p. 9.

[53] Fols. 25v and 93v: M. BROWN, *Lindisfarne Gospels and the Early Medieval World* (supra n. 31), pls. VIII and XIV; R. GAMESON, *From Holy Island to Durham* (supra n. 31), ills. 4 and 18. In this respect Eadfrith's work anticipates that of the so-called « divisionist » painters, such as Seurat and Signac, at the end of the nineteenth century. The use of brown/black lines and details aside, the most obvious areas of over-painting and/or intermixing of colours are the grey and white of Matthew's hair, the red and yellow motifs on the cushion of Luke and the stool and robe of John, along with the white on brown of John's eagle – all, it will be noted, within the figural imagery.

suggested that these dramatic colour contrasts were designed to evoke divine radiance[54]. Be that as it may, such principles were certainly in accord with the native « separationist » approach to colour more generally – not to mention being a surer means of avoiding adverse chemical reactions.

The full significance of the fact that gradations of tone were indeed used in manuscript illumination at Wearmouth-Jarrow has not been fully appreciated hitherto: when seen in relation to the general eschewal of such approaches in Northumbrian manuscript art as a whole, it can be recognised as no less striking a witness to the twin community's wish to emulate « Roman » culture than was its adoption of Uncial script or even its summoning of foreign stone-masons and glaziers. Correspondingly, in the context of most Northumbrian illumination – effectively a world of juxtaposed pigments - the occasional instance of overlaying colours could be arresting: the yellow dots on the purple head of John's eagle in the Cambridge-London Gospels are a case in point, the dotted initials in the Lindisfarne Gospels another.

The third and final point, which develops the previous observation, is that there were different traditions concerning how colour was used. The divergent approaches to colouring figural subject matter at Wearmouth-Jarrow and Lindisfarne have just been mentioned. But the contrasts extended beyond illumination per se, to different ways of deploying colour in the presentation of scriptural text itself. Following their Italian exemplars, scribes at Wearmouth-Jarrow set out biblical texts *per cola et commata*, using red to distinguish the initial letters heading capitulum divisions and sometimes also Eusebian sections. A line of red provided an additional accent at the start of the text as a whole. Scribes working in Insular traditions, by contrast, tended to favour long-line layouts and then highlighted Eusebian sections, capitulum divisions, and certain new sentences by enlarged initials, vividly coloured;

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[54] H. PULLIAM, « Eyes of Light: colour in the Lindisfarne Gospels », *Newcastle and Northumberland: Roman and Medieval Art and Architecture*, ed. J. ASHBEE and J. LUXFORD (British Archaeological Association Conference Transactions 36), 2013, 54-72 at 68.

they gave the beginning of the texts altogether greater, polychrome accents. This was quite literally a more colourful and decorative means to the same end. In the Lindisfarne Gospels the two techniques were combined; and the same is true in more modest ways of the Royal-Athelstan Gospels. If the Italian Vulgate text-type and *per cola et commata* layout of the Lindisfarne Gospels declared its affiliations to the continental church (arguably then perceived as the « church universal »), the many coloured initials subdividing and articulating that text broadcast its continuing espousal of an Insular heritage no less clearly than did the decoration of initials, the inclusion of carpet pages, and the use of Insular Half-Uncial script.

In sum, colour stands alongside codicology, script type and word separation as something that was initially utilised differently by scribes within Insular traditions as opposed to those working under stronger Continental influence. It is clear that by the end of the seventh century there was cross-fertilisation between « Insular » and « Continental » approaches to codicology and script, and the same point is made by the way colour was deployed in the Lindisfarne and Royal-Athelstan gospels. However, the actual pigments used were - as our investigations have underlined - much the same from one tradition to another, doubtless reflecting the availability and supply of relevant materials. And if it is natural to admire the extended palettes of the Lindisfarne Gospels and Codex Amiatinus (as of the Book of Kells), one should perhaps be more impressed by the arrestingly beautiful results that were achieved in the Durham and Cambridge-London Gospels with a smaller and arguably more typical range of pigments[55].

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[55] We are very grateful to the institutions and individuals whose support brought this logistically complicated project to fruition. The Master and Fellows of Corpus Christi College, Cambridge, and the Dean and Chapter of Durham Cathedral graciously gave permission for their manuscripts to be studied; their invariably helpful library staff facilitated this. In addition, both institutions have kindly permitted us to reproduce details from their manuscripts as illustrations. At Palace Green Library, Dr Sheila Hingley, Head of Heritage Collections, worked to provide suitable accommodation for the project while

Pigment Analysis at Durham, 2013

Experimental

The selection of pages that would be both representative and potentially the most revealing for pigment analysis was informed by detailed knowledge of the volumes and their codicological structure. Investigation of each such page via hyperspectral imaging and diffuse reflectance permitted a preliminary identification of the compounds that were present based on their absorption profiles; this in turn guided the choice of laser wavelength for Raman spectroscopy. Of each page to be studied high resolution digital photographs were taken, on which were recorded the points from which data were collected.

Diffuse reflectance spectra were obtained by the illumination of a 5 mm diameter region of the manuscript with the output of a tungsten halogen lamp. The non-specular scattered light was collected

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much of the building was occupied with a major exhibition; Liz Brannigan, senior conservator, managed to find time to oversee the handling of the manuscripts during the particularly busy periods of installing and de-installing the exhibition; and Caroline Craggs took the reference images essential for documenting the campaign of work – often at very short notice. R. J. H. Clark, B. Meehan and A. W. Parker gave generously of their time and expertise, advising on procedures, drawing attention to comparanda, and subjecting an earlier draft of this article to careful scrutiny. Last but very definitely not least, we thank Rob and Felicity Shepherd whose initial interest was the crucial catalyst for the project as a whole and whose generous subvention permitted the relocation of the spectrometer, the assembly of the core team, not to mention the invaluable sessions with the consultants.

and analysed using a spectrograph-CCD spectrometer (Ocean Optics MAYAPro). The reflectance spectrum was recorded as the ratio of the spectra obtained from the manuscript against a standard white material, Spectralon®. Hyperspectral images were recorded with a CCD-camera equipped with a series of narrow-band optical interference filters. The manuscript was illuminated using a low-power tungsten lamp and images recorded using each filter. Images were then combined to generate false-colour representations indicating the location of pigments, using custom software written in LabVIEW.

Raman spectra were recorded with a Horiba LabRAM-HR Raman microscope spectrometer equipped with a 'free-space' microscope. The books were placed on a supporting conservation cushion located on a moveable table that permitted easy movement of the book under the microscope in the x, y plane. Focusing was achieved through the movement of the objective lens in the z direction.

Prior to any work involving either a test specimen or a medieval manuscript, the spectrometer was first calibrated using a standard sample. Thus, after allowing the laser at least fifteen minutes to stabilise, the spectrum of silicon, toluene or cyclohexane was recorded in order to allow wavenumber calibration to <1 cm^{-1}, with reference to the silicon band at 520 cm^{-1}. The power of the laser at the sample (i.e. after passage through the objective lens) was then measured with a power meter. The laser beam was attenuated using neutral density filters to give a laser power of < 0.4 mW for both the 633 and 532 nm lasers with the x50 or x100 long-working distance objective lenses.

The laser power was carefully measured prior to measurements being made on manuscripts. The power densities used in the present campaign were significantly less than those used by other recent workers. (Bioletti *et al.* (see note 2), for example, deployed 50 x lens, 2.25 mW, and Miguel *et al.* (see note 12) 50 -100x min power 17 - 0.17 mW.) Furthermore, during data acquisitions, close attention was paid to the sample area to ensure that no thermal damage was occurring. No changes in the spectral signature or intensity on a shot-to-shot basis were detected during an acquisition, nor were any fluctuations observed in the speckle pattern of the scattered laser light from the sample. (Minute changes in sample surface structure give rise to exaggerated movements in the speckle pattern.)

All measurements were undertaken with the room-lighting extinguished, in order to avoid 'false' peaks from the mercury plasma lines in the fluorescent tubes. While each point on the page to be investigated was assessed individually for the precise settings that would achieve the optimum spectrum, the following are indicative of typical conditions:

- 633 nm laser, 0.3 mW (10% ND filter), spectral range 100-1300 cm^{-1}, -10 x 5- second acquisitions summed and averaged;
- 532 nm laser, 0.35 mW (10% ND filter) spectral range 100-1500 or 1900-3300 cm^{-1}, 10 x 5-second acquisitions summed and averaged (60 x 5- second acquisitions summed and averaged for copper-based samples).

The raw spectra acquired during the measurements contain artefacts arising from the optical filters used to inject and reject the laser line into the spectrometer. These artefacts have been removed from the spectra by a two-step process: first the 'ripple' associated with interference effects in the optical filters was eliminated by ratioing the recorded spectrum with one recorded using a white light source; secondly, the underlying broad-band fluorescence was removed using the instrument-maker's software. The spectra displayed in the figures are normalised for clarity.

Pigments were identified by reference to spectra published in the literature (I. M. BELL, R. J. H. CLARK and P. J. GIBBS, *Raman Spectroscopic Library of Natural and Synthetic Pigments*) and by comparison to spectra obtained from commercial samples purchased from L. Cornelissen & Son, London. Of particular significance is the identification of massicot in some areas of red lead, and the differentiation of this from the closely related pigment litharge (BELL, CLARK and GIBBS, *Raman Spectroscopic Library*). Thus massicot shows bands in the Raman spectrum at 87 w, 143 vs, 289 s and 385 w cm^{-1}, whilst litharge has bands at 145 vs, 285 vw and 336 w cm^{-1}. The band positions for the two isomerics are almost within experimental error, and hence we rely upon the relative band intensities to differentiate between them: in each case we see evidence for the band at 298 cm^{-1} which is approximately ¼ the intensity of that at 143 cm^{-1}. In the case of litharge, the band at 285 cm^{-1} is much less intense (< $1/20^{th}$), allowing us confidently to assign the spectra to the orthorhombic PbO, massicot.

Results

Cambridge, Corpus Christi College, 197B

Fol. 1r (examined 2-x-2103)

The bright green pigment that forms the inner frame to the image of John's symbol, the eagle, is identified as a copper-based pigment, verdigris. Identification from the Raman peak ~2800 cm^{-1} was complemented by the evidence (obtained via diffuse reflectance spectroscopy) of strong absorption in the near infrared (> 800 nm). Furthermore, the paint, heavily applied, has bled through, penetrated and indeed eroded the parchment, reflecting the well-known acidity and corrosive nature of verdigris. The inscription 'Imago aquilae' was written in red lead, its hue here a vibrant orange. The head of the eagle was painted in an organic purple (see below), articulated with dots of orpiment. The application of orpiment onto an organic pigment avoided the risk of its reacting and blackening over time.

Fol. 2r (2-x-2103)

The yellow was orpiment, the green verdigris. The purple, based on its fluorescence profile, was probably orcein dye; the dark red deployed for the knotwork within the body of the initial was also fluorescent and is suspected to be the same material; no Raman spectra could be obtained from this. The red-lead on this page proved to be a mixture of lead oxides: the spectra of red minimum with traces of yellow massicot were evident in the various areas that were explored (for instance, the inscription).

Fol. 2v (2-x-2013)

The curiosity on this otherwise typical folio appeared in the apparatus denoting the sections for the first five lines of text. Despite appearing similar in hue to the red lead that was used elsewhere on the page, these characters do not give a Raman spectrum and may therefore be an organic pigment - raising the further possibility that they were added as a different phase of work.

Fols. 6v, 9r, 16r (2-x-2013; 3-x-2013)

These folios were selected to determine whether the range of pigments remained constant throughout the book - as indeed proved to be the case. This was true even when they were deployed in slightly different ways (the red of the dots that were applied over black ink, for instance, was still red lead).

Durham Cathedral Library, A.II.10

Fol. 2r (examined 3-x-2013 and 4-x-2013).

The blocks of colour within the decorated initial 'N' were orpiment, red lead, indigo, and an intimate mixture of indigo and orpiment that is referred to as vergaut. Dots of a contrasting colour were applied on top of these blocks as a decorative border – red lead on orpiment, orpiment on red lead, indigo and vergaut – a procedure that continued across the geometrical, double-headed serpent that forms the cross-bar. The finials of the uprights are in-filled with fine lines of red lead, as is the tail of the 't' in the continuation lettering. Enhanced letters within the text (denoting the Eusebian sections) are filled with orpiment. Some of the red lead has discoloured to light grey, and this does not yield any meaningful spectra.

An unusual aspect of this page was the presence of a tiny speck of pararealgar mixed in with the red lead above the vergaut on the right-hand side of the 'N' – the only instance of this pigment that we have encountered during the current project. As it cannot have resulted from contamination during our work, it must be assumed to be an original deposit. Regrettably, this intriguing speck was so minute that it was impossible to relocate in order to repeat the measurement. (It will be appreciated that, as the area sampled by the laser beam is a mere 5 □ m, the task of locating exactly the same spot twice is akin to looking for a needle in a haystack - the chance of succeeding a mere one in a million.) In this connection it is worth noting that, as realgar and pararealgar are often found alongside deposits of orpiment, their general absence from the pigments suggests that the mineral samples were carefully screened.

Fol. 3v (4-x-13).

The knot-work in the monumental 'D'-shapes that frame the colophon was orpiment overlaid with red lead dots. Given that red lead (Pb_3O_4) will react with orpiment (As_2S_3), the imposition of the one on the other was a bold strategy: many of the dots have indeed degraded and do not, as a consequence, yield good spectra. The interlace twists at the corners and between the 'D's were painted with red lead, orpiment, vergaut and indigo. The writing within the bowls of the 'D's is very faded, and it proved challenging to obtain Raman spectra from what remains. Nevertheless, weak spectra attributable to red lead were recorded from the residual text in the uppermost and lowermost bowls.

Durham Cathedral Library, A. II.16

Fols. 33v, 37r (27-v-2013)

The yellow colour within the decorated initial 'I' for Mark's Gospel did not yield any significant Raman signal: indeed, the signal was very like that of the virgin parchment nearby. More binding medium than pigment appears to have been used in this paint. The accompanying display script featured red lead (now rather degraded). To the eye, the marginalia would appear to have been done in the same red; however, the spectrometer revealed a Raman signal for massicot as well as minium (two forms of lead oxide) – as was occasionally observed in CCCC 197B. Since there had evidently not been any contamination, this would indicate that two different batches of red ink, prepared separately, were used on the page (the massicot arising from the incomplete roasting of the lead used to make minium).

Fols. 123v, 130r.

In John's Gospel liberal use was made of orpiment for filling the bowls of minor initials, and of red-lead dots for outlining them; however, the two pigments were never brought into direct contact. Again, massicot as well as minium were observed in the red.

Durham Cathedral Library, A.II.17, part 1

Fol. 1r (29-v-13)

The incipit page to the Gospel of John, now the first folio of this part of the manuscript, is very weathered and the pigment shows signs of degradation. Observed under the microscope, the surface glaze has a dark, grubby appearance – in effect, a sombre filter obscuring the colours below. The three colours used in both the initial monogram and the continuation lettering are yellow, purple and green. The yellow gave a spectrum consistent with orpiment. The purple did not provide a meaningful Raman spectrum; however, its fluorescence profile under laser illumination was more like that of orcein than that of Tyrian Purple. The green was verdigris, as was confirmed by the combined evidence of resonance Raman spectroscopy (using the 532 nm laser for longer exposure times, identifying a peak at ~2800 cm^{-1}), diffuse reflectance, and hyperspectral imaging (it displays the strong absorption in the infrared region of the spectrum that is typical of a copper-based pigment).

Fol. 1v (29-v-2013)

The major initial «F», the line of monumental display capitals that accompanies it (John 1.6), plus the three more modest initials that mark Eusebian sections all feature blocks of verdigris green and orpiment yellow plus red lead ornamentation, but (in contrast to the recto of the leaf) there is no purple. Uncharacteristically, the orpiment here does not give a strong Raman signal; however, observation under the microscope suggests that this is a consequence of the very dark layer of binding medium covering the paint.

Fols. 2v and 3r (28-v-2013)

Typical of much of the manuscript, these pages have minor decorated initials painted with yellow orpiment, green verdigris, and a purple that is probably orcein, all articulated with dots of red lead; red lead was also used for the running heading 'Iohannes'. Here - in contrast to the practice seen in DCL A.II.10 - space (in the form of virgin parchment) was reserved between the red-lead and the orpiment. This was presumably to avoid the possibility of blackening that can result from the chemical reaction between these two compounds - suggesting that the scribe-artist had observed this effect elsewhere and knew that contact between them could result in their degradation.

Fol. 38(3)v (31-v-2013)

This early Insular image of the Crucifixion has suffered severe damage from a period when it was redeployed as a paste-down, and from over-exposure to light. The adhesive applied when it was a paste-down now forms a dark layer covering and obscuring the pigments. Certain areas - which yielded no Raman spectra, or spectra that are inconsistent with the remainder of the page (as indeed with the rest of the manuscript as a whole) - would appear to have been subject to interventions or conservation at some point prior to modern records. Raman spectra from the badly degraded inscription around the border, along with the cross and the nails in Christ's hands, did provide evidence for the use of red lead. The characteristic spectrum of orpiment was obtained from the folds of the robe and the feathers of the seraphim. The hint of faded blue that is apparent to the naked eye in the wings of the seraphim did not offer any Raman spectra. The green gave a very weak spectrum of copper type: considerably less clear than in the rest of the manuscript, this identification is reliant upon the supporting witness of near infrared imaging and diffuse reflectance spectra. In common with the rest of the book, the purple did not yield a meaningful Raman spectrum; however, the fluorescence profile that masks the signal was similar to that of orcein samples prepared in our laboratory. (Compare A. DAVERI, C. CLEMENTI, A. ROMANI, S. BIOLETTI, B. BRUNETTI, A. SGAMELLOTTI and C. MILIANI, « The Book of Kells: a non-invasive MOLAB investigation by complementary spectroscopic techniques », *Spectrochemica Acta Part A: Molecular and Biomolecular Spectroscopy* 115, 2013, 330-336.)

Fol. 38(4)r (29-v-2103; 31-v-2013)

The line of decorative lettering that heads the capitula list for Mark contains many discrete blocks of colour. Diffuse reflectance and hyperspectral imaging confirmed the green and purple to be copper-based verdigris, and orcein respectively. The body of the initial 'D' is filled with orpiment knotwork, leading to a verdigris dragon head, outlined by red lead dots. Red lead was also used for the running heading.

Fol. 39r (31-v-2103)

« Abba » and « Marcus » are decorated with blocks of orcein purple and orpiment, outlined by red-lead dots. Several lines of text in the middle of the page were written in red lead, with scroll-work line-fillers in the same pigment.

Fol. 68v (6-vi-2013)

Typical of the manuscript, the initials were ornamented with orpiment, verdigris, and a purple that displayed a fluorescent profile indicative of orcein. Red lead was used for the dots, the running heading, and the marginal apparatus; in the case of the last, visual inspection revealed that it had degraded to a much darker colour, indicating reduction to metallic lead or lead sulfide.

Fol. 69r (3-vi-2013; 6-vi-2013)

The fine « Et » at the bottom of this page is one of the best-preserved sections of artwork in the manuscript. The interlace was coloured with orpiment and verdigris, as was established by both Raman spectroscopy and hyperspectral imaging (the strongly-absorbing copper pigment appearing particularly dark in infrared images); the dots were composed of red lead. The initials for Eusebian sections feature the familiar orpiment yellow, copper-based green, and organic (probably orcein) purple.

Durham Cathedral Library, A.II.17, part 2

Fol. 106r (3-vi-13)

Parts of the marginal apparatus, as also the added sketch of a lion head, contain red lead. No colour was used otherwise. The black ink did not yield a Raman spectrum; however, hyperspectral imaging revealed that it was not strongly absorbing in the near infrared spectral region, indicating that it was likely to be based on iron gall. The black ink used for the original marginal apparatus was more transparent in the near infrared region of the spectrum than that of the additions made at Chester-le-Street in the tenth century (with the exception of the added name, « Aldred »).

Durham Cathedral Library, B.II.30

Fols. 5v, 81v, 172v, 212v (17-vi-2013)

The decorated initial « d » on 212v was delicately drawn in black ink, enhanced with red-lead dots. The dots that articulated the comparable initial on 5v were badly degraded - almost white. It was considered that measuring their spectra would have required illumination power densities and acquisition periods beyond those which we had set as safe for this exercise, and hence they were not explored further.

The colours in the two full-page miniatures (81v, 172v) were very faded, probably from over-exposure to light. The only pigments successfully identified were the orange and green used within the frames, which were red lead/massicot mixtures and verdigris respectively. David's purple robes, the colour of which is now very faint, failed to yield a Raman spectrum. A yellow pigment appeared to have been used as a glaze over the parchment. Not orpiment, this was unidentifiable; however, it invites general comparison with the non-orpiment yellow that was deployed in a very dilute form in DCL A.II.16.

Durham Cathedral Library, B.IV.6, fol. 169*

(27-v-13). No Raman spectra.

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APPENDIX

Northumbrian Manuscripts and their Pigments, a summary

The analysis of the Cambridge and Durham books was done by the Durham team. The sources for the identifications of the pigments in the manuscripts in Florence and London are given after each, full bibliographical details appearing in note 2 above.

Cambridge, Corpus Christi College 197B ('The Cambridge-London Gospels')

Red: red lead; red lead + massicot mixture

Yellow: orpiment

Green: copper-based/verdigris

Purple: organic (orcein)

Black: iron gall.

Durham Cathedral Library, A.II.10 (Gospel-book or New Testament)

Orange: red lead

Yellow: orpiment

Green: vergaut

Blue: indigo

Black: iron gall

Durham Cathedral Library, A.II.16 (Gospel-book)

Red: red lead, and red lead + massicot mixture

Orange: red lead

Yellow: organic dye; (John alone) orpiment

Durham Cathedral Library, A.II.17 (part 1) (The Durham Gospels)

Red/orange: red lead, and red lead + massicot mixture

Yellow: orpiment

Green: verdigris

Purple: organic ?orcein.

Durham Cathedral Library, A.II.17 (part 2) (Wearmouth-Jarrow Gospel-book)

Red: red lead.

Durham Cathedral Library, B.II.30 (The Durham Cassiodorus)

Orange: red lead

Yellow: organic dye

Green: copper-based (verdigris)

Purple: organic

Florence, Biblioteca Medicea-Laurenziana, Amiatino 1 (Codex Amiatinus)

Red: red lead; organic lakes; earths

Yellow: orpiment; organic lakes; earths

Green: vergaut; verdigris (plus unidentified organic compound)

Brown: earth colours (iron and copper mixed with orpiment or gold)

Grey: a white mixed with blue and carbon black, or silicates with copper and iron

White: calcite; white lead

Metallic inks: combinations of copper, lead, silver, gold plus orpiment or iron earths

(Identifications: BICCHIERI *et al.*, « Non-Destructive Analysis of Bibbia Amiatina ».)

London, British Library, Cotton Nero D. iv (The Lindisfarne Gospels)

Red: red lead

Yellow: orpiment; organic dye

Green: verdigris; vergaut

Blue: indigo

Purple: organic dye

Pink: white lead or chalk plus organic dye

Black: iron gall; sometimes with carbon

Metallic gold

(Identifications: BROWN and CLARK, « The Lindisfarne Gospels and Two other Eighth-Century Anglo-Saxon/Insular Manuscripts ».)

London, British Library, Royal 1 B. vii (The « Royal Athelstan » Gospels)

Red: red lead

Yellow: orpiment

Green: vergaut

(Identifications: BROWN and CLARK, « The Lindisfarne Gospels and Two other Eighth-Century Anglo-Saxon/Insular Manuscripts ».)